

MIL-I-2781B

3 SEPTEMBER 1954

SUPERSEDING

MIL-I-2781A

23 January 1953

MILITARY SPECIFICATION

INSULATION PIPE COVERING, THERMAL

This specification has been approved by the Department of Defense for use of the Departments of the Army, the Navy and the Air Force

1. SCOPE

1.1 **Scope.**—This specification covers requirements for thermal insulation used for covering pipes.

1.2 **Classification.**—The thermal insulation pipe covering shall be of the following grades and classes, as specified (see 6.1) :

Grade I—Temperatures up to 500°F.

Class b—Compounded.

Grade II—Temperatures up to 750°F.

Class c—Fibrous.

Class d—Compounded.

Grade III—Temperatures up to 1,050°F.

Class e—Compounded.

Type I—Calcium silicate.

Type II—Diatomaceous earth.

Class f—Fibrous.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on date of invitation for bids, form a part of this specification :

SPECIFICATIONS

FEDERAL

NN-B-591—Boxes, Fiberboard, Wood-Cleated (for Domestic Shipment).

NN-B-621—Boxes, Wood, Nailed and Lock-Corner.

LLL-B-631—Boxes, Fiber Corrugated (for Domestic Shipment).

LLL-B-636—Boxes, Fiber, Solid (for Domestic Shipment).

PPP-B-601—Boxes, Wood, Cleated-Plywood.

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JAN-P-106—Packaging and Packing for Overseas Shipment — Boxes, Wood, Nailed.

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JAN-P-108—Packaging and Packing for Overseas Shipment—Boxes, Fiberboard (V-Board and W-Board), Exterior and Interior.

MIL-L-10547—Liners, Case, Waterproof.

STANDARDS

MILITARY

MIL-STD-105—Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-129—Marking of Shipments.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

2.2 **Other publications.**—The following document forms a part of this specification. Unless otherwise indicated the issue in effect on date of invitation for bids shall apply :

CONSOLIDATED CLASSIFICATION COMMITTEE

Consolidated Freight Classification Rules.

(Application for copies should be addressed to the Consolidated Classification Committee, 202 Chicago Union Station, Chicago 6, Ill.)

3. REQUIREMENTS

3.1 **Qualification.**—The thermal-insulation pipe covering furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein (see 6.2).

3.2 **Material.**—The pipe covering shall be composed of heat-resisting compounds suitable for the temperature conditions and the purpose intended.

3.3 **Composition.**—The pipe covering shall conform in all respects to the composition obtained on the sample submitted for qualification (see 4.3.2).

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3.4 Stability.—The pipe covering shall pass the vibration test specified in 4.3.3.

3.5 The pipe covering shall conform to the physical requirements shown in table I.

3.6 Length and form.—Pipe covering sections shall be furnished in lengths of 3 feet, split in half lengthwise for nominal pipe sizes up to and including 10 inches. Pipe covering for sizes larger than 10 inches may be furnished in segments or sections.

3.6.1 Tolerance.—A tolerance of plus or minus $\frac{1}{8}$ inch in length will be permitted.

3.7 Thickness.—Insulation pipe coverings shall be manufactured according to the thickness standards (see Note) shown in table II and furnished as specified. (See 6.1.)

3.7.1 Thickness tolerances.—A tolerance of plus $\frac{1}{8}$ or minus $\frac{1}{16}$ inch in actual thickness shown in table II will be permitted.

3.7.2 Pipe covering may be furnished in two layers to form total required thickness.

3.8 Sectional pipe covering, grade I, class B; grade II, class D, and grade III, class E, up to and including $1\frac{1}{2}$ -inch pipe size, shall be furnished with a cloth or paper jacket covering the entire length.

3.9 Workmanship.—The workmanship shall be first class in every respect.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling.

4.1.1 Lot.—For purposes of sampling, a lot shall consist of all half sections or segments of pipe covering of the same grade and class produced in one plant under essentially the same conditions and offered for delivery at one time.

4.1.2 Sampling procedure for inspection at the place of manufacture.—A random sample of half sections or segments shall be selected in accordance with table III from each inspection lot of material offered for Government inspection.

TABLE I.—Physical requirements

Characteristics	Method of test, paragraph	Grade I	Grade II		Grade III		Class f
		Class b	Class c	Class d	Class e		
					Type I	Type II	
Density lbs./cu. ft. maximum.....	4. 3. 4	13. 00	15. 00	13. 00	13. 00	27. 00	25. 00
Thermal conductivity:							
B. t. u./hr./sq. ft./°F./inch maximum, at a mean temperature of:							
300° F.....		. 50					
400° F.....	4. 3. 5		. 50	. 53			
600° F.....					. 65	. 80	. 65
Hardness, penetration, mm. maximum.....	4. 3. 6	1. 15	. 40	1. 00	1. 00	1. 00	. 40
Resistance to abrasion, percent:							
Loss in weight, maximum:							
After first 10 minutes.....	4. 3. 7	40		40	40	55	
After last 10 minutes.....		70		70	70	80	
Modulus of rupture, lbs./sq. in., minimum.....	4. 3. 8	(¹)		(¹)	(¹)	(²)	
Changes under soaking heat for 6 hours at — °F.....		500	750	750	1, 050	1, 050	1, 050
Hardness, mm. penetration maximum.....	4. 3. 6	1. 40	. 70	1. 15	1. 25	1. 25	. 70
Loss in weight, percent, maximum.....	4. 3. 9	18. 00	6. 00	12. 00	12. 00	16. 00	6. 00
Linear shrinkage, percent, maximum.....	4. 3. 9	2. 00	1. 00	2. 00	2. 00	2. 00	1. 00
Moisture absorption, percent by volume, maximum.....	4. 3. 10	1. 00	2. 00	3. 00	3. 00	3. 00	2. 00

¹ Three times density (lbs. per. cu. ft.) of the sample tested.

² Two and one-half times density (lbs. per cu. ft.) of the sample tested.

TABLE II.—Thickness

Iron pipe size		Nominal 1 inch thick	Nominal 1½ inches thick	Nominal 2 inches thick	Nominal 2½ inches thick	Nominal 3 inches thick	Nominal 3½ inches thick	Nominal 4 inches thick
Nominal	O. D.	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness	Actual thickness
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
½	0.840	1	1½	2½	2¾	3½	3¾	4¾
¾	1.050	1½	1¾	2½	2¾	3¾	3¾	4¾
1	1.315	1½	1¾	2½	2¾	3¾	3¾	4¾
1¼	1.660	1½	1¾	2½	2¾	3¾	3¾	4¾
1½	1.900	1½	1¾	2½	2¾	3¾	3¾	4¾
2	2.375	1½	1¾	2½	2¾	3¾	3¾	4¾
2½	2.875	1½	1¾	2½	2¾	3¾	3¾	4¾
3	3.500	1½	1¾	2½	2¾	3¾	3¾	4¾
3½	4.000	1½	1¾	2½	2¾	3¾	3¾	4¾
4	4.500	1½	1¾	2½	2¾	3¾	3¾	4¾
4½	5.000	1½	1¾	2½	2¾	3¾	3¾	4¾
5	5.563	1½	1¾	2½	2¾	3¾	3¾	4¾
6	6.625	1	1½	2½	2¾	3¾	3¾	4¾
7	7.625		1½	2½	2¾	3¾	3¾	4¾
8	8.625		1½	2½	2¾	3¾	3¾	4¾
9	9.625		1½	2½	2¾	3¾	3¾	4¾
10	10.750		1½	2½	2¾	3¾	3¾	4¾
11	11.750		1½	2½	2¾	3¾	3¾	4¾
12	12.750		1½	2½	2¾	3¾	3¾	4¾
14	14.000		1½	2	2½	3	3½	4
Up to and includ- ing 33			1½	2	2½	3	3½	4

Note.—The feature of these thickness standards is the O. D. of pipe insulation which is approximately the same as the O. D. of iron pipe sizes. Insulation can be applied either to a pipe or as a second layer to a smaller size of pipe insulation.

TABLE III.—Sampling for visual, dimensional, and density inspection AQL (approx.) = 2.5 percent defective

Number of half sections or seg- ments in inspection lot	Number of half sections or segments in sample	Acceptance number (defectives)	Rejection number (defectives)
40 and under	5	0	1
41 to 110	7	0	1
111 to 500	10	0	1
501 to 1,300	15	1	2
1,301 to 3,200	25	1	2
3,201 and over	35	2	3

Note.—The Government inspector shall institute tightened inspection in accordance with Standard MIL-STD-105. Reduced inspection may be instituted by the Government inspector in accordance with Standard MIL-STD-105.

tion of visual, dimensional, and density characteristics, with lot acceptance based on sampling inspection requirements in accordance with Standard MIL-STD-105.

4.1.3 Sampling procedure for lot acceptance at the place of manufacture.—A random sample of half sections or segments shall be selected from each inspection lot in accordance with table IV for the tests specified in 4.2.2.

4.1.4 Sampling procedure—for production check tests at a Government laboratory.—From the first lot offered for delivery under a contract or order, and thereafter from one of every ten lots which have passed inspection and tests at the place of manufacture, the Government inspector shall select two half sections or segments for the tests specified in 4.2.3. Unless otherwise specified in the contract or order, test

TABLE IV.—*Sampling for lot acceptance tests*

Number of half sections or segments in inspection lot	Number of half sections or segments in sample	(Number of items nonconforming on any lot acceptance test)	
		Acceptance number	Rejection number
40 or under.....	2	0	1
41 to 110.....	3	0	1
111 to 500.....	5	0	1
501 to 1,300.....	7	0	1
1,301 and over....	10	0	1

shall be conducted at the U. S. Naval Engineering Experiment Station, Annapolis, Md.

4.2 Inspection and tests.

4.2.1 Visual and dimensional and density inspection.—Each of the sample half sections or segments selected in accordance with table III shall be visually and dimensionally inspected and the density determined (see 4.3.4) by the Government inspector to verify compliance with this specification. Any half section or segment in the sample containing one or more visual, dimensional, or density defects shall be rejected, and if the number of defective half sections or segments in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected. Rejected lots may be offered again for Government inspection provided the contractor has repaired or removed all nonconforming half sections of segments. The Government inspector shall again select and examine samples from such resubmitted lots to verify compliance with this specification.

4.2.2 Lot acceptance tests at the place of manufacture.—Two specimens from each of the sample half sections or segments selected in accordance with 4.1.3 shall be subjected to the tests specified in 4.3.6 and 4.3.8. If any one of the sample specimens tested is found to be not in conformance with the specification, the lot which it represents shall be rejected.

4.2.2.1 Action in case of failure.—A rejected lot may be resubmitted for Government inspection only after the manufacturer, after being informed of the reasons for rejection, has so

reworked the entire lot as to remove or correct all nonconforming material.

4.2.3 Production check tests at a Government laboratory.—The sample half sections or segments selected in accordance with 4.1.4 shall be subjected to any of the tests specified in 4.3 deemed necessary by the Government laboratory to determine that the samples conform with that given qualification.

4.2.3.1 Action in case of failure.—Except as hereinafter specified, acceptance and rejection of lots shall normally be on the basis of the sampling, inspection and tests of 4.1.2, 4.1.3, 4.2.1 and 4.2.2, and acceptance shall not be withheld pending receipt of production check test reports unless in the opinion of the Government inspector circumstances require such action. However, upon receipt of an unsatisfactory test report on a production check test sample, the Government inspector shall select additional samples from each subsequent lot offered for delivery. The samples so selected shall be submitted to the Government laboratory, and shall there be subjected to the test or tests wherein failure was observed. Lots shall then be accepted only upon receipt of a satisfactory test report on the samples so selected. This additional testing shall be discontinued and lot acceptance returned to the normal basis when four successive lots have been accepted.

4.3 Test procedures.

4.3.1 Conditioning samples.—Test specimens for inspection and for tests shall be dried to constant weight by heating to 220° to 230° F. (105° to 110° C.).

4.3.2 Composition.—The composition shall be determined by chemical analysis, using accepted laboratory methods.

4.3.3 Stability.—The ability of the pipe covering materials to withstand vibration shall be determined from sections of the covering which have been subjected to the maximum pipe temperature for the respective grade for a period of 100 hours. The sections then shall be applied and secured between two circular 9½ inch diameter metal disks located 36 inches apart on a section of nominal 3-inch pipe. The pipe, with the material applied, shall be connected in a horizontal position in a vibration machine. In this position the materials shall be subjected

to 720 vibrations per minute through an arc of 15 minutes with a radius of 30 inches, for a period of at least 96 hours.

4.3.4 Density.—Half sections shall be carefully measured and weighed, from which the density shall be determined.

4.3.5 Thermal conductivity.—For this test, the sample shall be a 3-foot sectional cover for a 3-inch pipe. Conductivity shall be determined on a pipe-test apparatus at several temperatures up to 500°, 750° and 1,050° F., respectively.

4.3.6 Hardness.—Hardness shall be determined on the plastometer, a commercial instrument consisting mainly of two parallel metal disks supported on uprights, to which are fastened a thin rod with a 1/8-inch diameter ball point, measuring gage graduated in 1/100 mm. divisions, and a kilogram weight. A specimen of the material to be tested shall be placed under the instrument, and the 1/8-inch ball point shall be brought down on the surface of the specimen corresponding to the outside as received, until the index hand on the measuring gage makes two complete revolutions. The kilogram weight shall then be slowly released from its supporting disk and allowed to rest on a shoulder of the ball point holder, causing the ball point to sink into the specimen. The depth that the ball point is depressed into the specimen shall then be read on the graduated measuring gage dial to 1/100 of a millimeter.

4.3.7 Abrasion test.—The structural strength shall be determined by the abrasion test. In this test, twelve 1-inch cube specimens of the material and twenty-four 3/4-inch oak cubes (specific gravity of the wood 0.65) shall be placed in an oak box having inside dimensions of 7 1/2 by 7 3/4 by 7 3/4 inches. The opening of the box shall then be closed and the box rotated about its own axis at a speed of 60 revolutions per minute for two 10-minute periods. At the end of each 10-minute period, the cubes of the material under test shall be removed from the box and weight, due to shall be determined to remove all prior to each test.

4.3.8 Modulus

termining the modulus of rupture of the materials shall consist of supporting specimens of the materials on 10-inch centers and suspending a load from a saddle centrally located on the specimens with an increase of load until the specimens are broken. The specimens shall be 12 inches in length and in quadrants from the inner and outer layers of pipe covering. The saddles and centers shall be constructed to conform to the curvature of the specimens. Ten specimens of each layer shall be used for the test. The modulus of rupture shall be the average of the results on all specimens. The following equation shall be used in computing the modulus of rupture:

$$S = \frac{0.25WD \left[\frac{R - 0.6(R^2 - r^2)}{(R^2 - r^2)} \right]}{0.3214 (R^4 - r^4) - \frac{0.2829 (R^3 - r^3)^2}{(R^2 - r^2)}}$$

Where:

S = Modulus of rupture (pounds per square inch).

W = Breaking load (pounds).

D = Distances between centers of supports (inches).

R = Radius of outer periphery of pipe-covering specimens (inches).

r = Radius of inner periphery of pipe-covering specimens (inches).

4.3.9 Heating loss and shrinkage.—Carefully sized specimens shall be placed in an electrically heated oven. Specimens shall be heated at 500°, 750°, and 1,100° F., respectively, for grades I, II, and III for 6 hours. After removal from the oven, the specimens shall be examined to determine loss in weight, linear shrinkage, and change in hardness.

4.3.10 Moisture absorption.—Duplicate specimens, each having a total area of 72 square inches, shall be subjected to an atmosphere of 90 percent, relative humidity at 120° F., dry-bulb temperature, for 6 hours. The increase in weight shall be noted and recorded as percentage increase in weight and volume.

4.4 Qualification tests at a Government laboratory.—Qualification tests shall be conducted at a Government laboratory designated by the Bureau of Ships. These tests shall consist of the tests specified in 4.3.

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5. PREPARATION FOR DELIVERY

5.1 Packing.

5.1.1 *For domestic shipment—immediate use.*—The pipe covering shall be packed in accordance with the manufacturer's commercial practice in containers in a manner to insure acceptance and safe delivery at destination. Containers shall comply with the Consolidated Freight Classification Rules or other regulations as applicable to the mode of transportation.

5.1.2 *For domestic shipment and storage.*—The pipe covering shall be packed in snug-fitting wood-cleated fiberboard, cleated plywood, nailed wood, corrugated, or solid fiberboard boxes conforming to Specifications NN-B-591, PPP-B-601, NN-B-621 or the special requirements of LLL-B-631 or LLL-B-636, respectively. Closure of the boxes shall conform to the applicable container specification. The gross weight of wood boxes shall not exceed 200 pounds, unless the weight of the individual item exceeds this amount. Fiberboard boxes shall not exceed the weight limitations of the applicable box specification.

5.1.3 *For overseas shipment.*—The pipe covering shall be packed in snug-fitting wood cleated plywood, nailed wood or fiberboard boxes conforming to Specification PPP-B-601, JAN-P-106, or symbol V3c or V3s of Specification JAN-P-108, respectively. Wood or wood cleated boxes shall be fitted with a sealed waterproof caseliner conforming to Specification MIL-L-10547 and appendix thereto. Shipping containers shall be closed and strapped in accordance with the appendix of the applicable container specification. The gross weight of wood boxes shall not exceed 200 pounds, unless the weight of the item exceeds this amount; of fiberboard boxes, 70 pounds.

5.2 **Marking.**—In addition to any special marking required by the contract or order, interior packages and shipping containers shall be marked in accordance with Standard MIL-STD-129. The nomenclature shall be the exact nomenclature approved under the contract or order.

6. NOTES

6.1 **Ordering data.**—Procurement documents should specify the following:

- Title, number, and date of this specification.
- Grade class and type required (see 1.2).
- Nominal thickness and pipe size (see 3.7.1).
- Whether preparation shall be for domestic shipment—immediate use, domestic shipment and storage, or overseas shipment (see 5.1).

6.2 In the procurement of products requiring qualification, the right is reserved to reject bids on products that have not been subjected to the required tests and found satisfactory for inclusion on the Military Qualified Products List. The attention of suppliers is called to this requirement, and manufacturers are urged to communicate with the Bureau of Ships, Navy Department, Washington 25, D. C., and arrange to have the products that they propose to offer to the Army, the Navy, or the Air Force, tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products covered by this specification may be obtained from the Chief of the Bureau of Ships, Navy Department, Washington 25, D. C.

6.3 Class a standard density material specified in Specification MIL-I-2781A has been deleted, as the manufacture of the material has been discontinued.

Patent notice.—When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

The sections then shall be secured between two circular metal disks located 36 inches from nominal 3-inch pipe. The material applied, shall be in horizontal position in a vibration position the materials shall be

MILITARY SPECIFICATION

INSULATION PIPE COVERING, THERMAL

This amendment forms a part of Military Specification MIL-I-2781B, 3 September 1954, and has been approved by the Department of Defense for use of the Departments of the Army, the Navy, and the Air Force.

Page 1, paragraph 1.2, lines 11 and 12: Delete and substitute:

"Type I—Light density.
Type II—Heavy density."

Page 2, table I, grade III, type II, requirement for "Thermal conductivity" delete ".80" and substitute ".70".

Custodians:

Army—Corps of Engineers
Navy—Bureau of Ships
Air Force

Other interest:

Army—OT
Navy—Y

12/14, etc
12/10
12/14
Fed. Sup. Class.
5640